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ABSTRACT

This article addresses the problem of ascertaining the most suitable learning environment for learning diagnostic skills in health education--specifically diagnostic reasoning and the selection of therapy--through the design, development, and evaluation of a videodisc program. It describes the design, development, and formative evaluation of a videodisc at the University of Twente (The Netherlands) to investigate the effectiveness of two different instructional modes, expository and interrogatory. It also indicates that the hypothesis being tested in evaluating this disk, which was based on the Tennyson and Cocchiarella model for concept learning, pertains to learning outcomes of the various instances; the sequence of instances; and the effects of contrasts in the variable attributes of instances. A discussion of the theoretical background includes abstraction theory, the hypothesis approach, prototype theory, and the Tennyson and Cocchiarella instructional design model. Details are given of the design and development of three modules; the rationale for selecting the videodisc medium; recording techniques, editing, screen design, and user-interface; technical state of the art of videodisc; and compression techniques. A description of improvements that were made based on a formative evaluation of a prototype videodisc concludes the article. (Contains 24 references.) (ALF)

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A videodisc program for the acquisition of diagnostic skills in health education

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The videodisc was developed in close cooperation with J. Schmitz and B. Reimerink, both from the laboratory of the Department of Educational Technology.

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A videodisc program for the acquisition of diagnostic skills in health education

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Abstract

In this article the problem is addressed of what the most suitable learning environment is for learning diagnostic skills in health education. A videodisc program was designed and developed to investigate the effectiveness of different instructional modes. The design was based on the Tennyson and Cocchiarella model for concept learning (Tennyson & Cocchiarella, 1986). The program contains a large number of expository and interrogatory instances of a medical concept. The hypothesis to be tested pertains to the learning outcomes of variation of instances, the sequence of instances and the effects of contrasts in the variable attributes of instances. The design process and the development process as well as the results of a formative evaluation will be presented in the context of instructional design theory.

Introduction

Two of the main components of health education are diagnostic reasoning and the selection of a therapy. An important question is what the characteristics are of an effective instruction which is intended to train diagnostic reasoning and the acquisition of therapeutic skills. From an instructional design point of view it can be defended that a videodisc is a suitable medium to realize these goals. In this article the design, the development and the evaluation of such a videodisc are discussed.

Theoretical background

In education people learn to interpret stimuli they are confronted with. This process is called concept formation or knowledge acquisition. Concept formation refers to the process, in which the student responds uniformly to a set of stimuli (Glaser, 1967). As a result of this process the student has the ability to categorize instances, to discriminate between instances and non-instances and to subsume a new instance in a concept class. A concept is defined by (non-) discriminative features. In the case of discriminative features attributes are involved, which can be identified in all instances of a class. As a result one can speak of defining, critical or criterium-attributes.

The traditional perspective on concept formation states, that concepts are formed by the fact that a subject abstracts from some resemblances between dissimilar stimuli (Bolton, 1983). This abstraction theory hypothesizes that a concept is a representation of generic features, which have been identified by many specific perceptions. A contrasting theory, the hypothesis approach, states that a concept is formed by the fact that a person

formulates a hypothesis regarding specific features of his environment. Consequently the subject can look for evidence, which (dis-) confirms the hypothesis.

Cohen and Murphy (1984) provided a classification scheme regarding concept learning. In this scheme a concept refers to a) a definition of a term, or a proposition regarding the defining conditions, under which something can be subsumed under a class, and b) a representation of knowledge, which can be used to categorize objects, events or processes. The perspective in which a concept is equivocal with a definition (see a), rests on an extensional or set-theoretical model, i.e. a concept is modelled as set of (necessary and sufficient) attributes.

Within cognitive psychology there is an increasing interest in non-defining attributes in concepts (Rosch, 1975; Smith, Rips, Shoben, 1974). In this approach representation (see b, above) was stressed: concepts are organised around the best example. This prototype is commonly conceived of as a mean member of the category, i.e. the prototype encompasses the
most frequent attributes of the members of the category. The prototype view of concept learning goes back to Wittgenstein (1953). He stated that the meaning of words can form family-resemblances and he concluded that the circumstances in which people use the same word for all examples are based on the fact that these instances have different relations in a complicated network of overlapping and crisscrossing similarities. This view is inconsistent with the classical abstraction theory., which assumes that a concept is a generalisation and that a concept represents the similarities between instances of a concept. Under that perspective a concept is modelled as set. One of the problems of this set-theoretical approach to concepts is, that it is impossible to specify what are the defining attributes of natural categories, i.e. objects with no clear boundaries. Examples of natural categories have some resemblance which partially explains why these examples are subsumed in the same class (Cohen, 1982; Quine, 1969). As a consequence it was concluded, that concepts are organised around a best example. This prototype (Rosch, 1978; Rosch & Mervis, 1975) is a mean member of a category; the most frequently encountered attributes are encompassed in this member of the category. The notion of best or typical example does not fit in the set-theoretical approach of concept formation. It does fit with the representational approach to conceptual development, which implies that concept formation can be seen as based on rules for (the construction of) complex representations. (Cohen & Murphy, 1984).

Prototype-theory hypothesizes that membership in the extension of a concept can be conceived of as gradient, i.e. determined by the resemblance to the most typical case. Consequently objects can not sharply be assigned inside or outside the extension of a concept. An object exemplifies a concept dependent on the resemblance to the prototype. The boundary between membership and non-membership is vague. A fuzzy concept can be modelled in a multidimensional space. In that case the value of the prototype in each dimension is the mean value of all instances on these dimensions. The less the (metrical) distance between object and prototype, the more typical the object is for that concept. (Rips, Shoben & Smith, 1973). Consequently fuzzy concepts are characterized by a membership function, which gives the degree of typicality for a category (Zadeh, 1966; Nowakowska, 1977).

Recently an instructional design model for concept-learning has been developed which incorporates (elements of) prototype-theory and which eliminates the deficiencies of the classical model (Merrill & Tennyson, 1977; Tennyson & Cochiarella, 1986; Tennyson & Ok Choon Park, 1980). As usual a concept is conceived as a set of specific objects, symbols or events which share (critical) attributes and which can be referred to by a name. As a result concept learning consists of the identification of concept-attributes which can be generalised to new or other instances and which discriminate examples from non-examples. Contrary to the classical approach Merrill and Tennyson (1977) hypothesize, that this process of concept formation is a deductive process. This process is based on classification, especially on generalisation and discrimination. Concept formation can be broken down into two phases. The first one is prototype-formation. Prototype denotes a typical example of a category which encompasses the common features of many examples. The second phase is classification, i.e. generalisation to new examples of a concept and discrimination between examples of different concepts. Typical research regarding prototypes consists of presenting instances of categories to students. After the learning process the students are asked to classify the instances. There is evidence that students can classify the instances more confidently depending on the resemblance of the instance to the typical case. Regarding the development of classification Tennyson et al. (1986) conclude that this ability will develop faster if examples of a concept vary from easy to difficult, secondly if examples diverge as to variable attributes and, thirdly, if examples are matched with non-examples (on the basis of similarity of variable attributes). The development of classification will also be facilitated by contrasting the prototype with new instances (correct and incorrect). This hypothesis was tested (Merrill & Tennyson, 1977) by comparing three presentation-forms of examples: a) exposition, b) interrogation, c) combination of exposition and interrogation. In all three conditions the training program was identical and the same definition of the concept was presented to the students. In the first case students got a rational set of examples and non-examples. It was hypothesized that this would result in a prototype. In the second case an interrogatory presentation of rational sets of examples and non-examples was given to the students. It was hypothesized that this would result in classification, not in prototype-formation. In the third case students got a combined expository-interrogatory presentation of rational sets of examples and non-examples. It was hypothesized that firstly a prototype would be formed in memory and secondly the ability of classification would be developed. As criterium some measures were used which were derived from the four levels of conceptual development, as developed by Klausmeier (Klausmeier & Goodwin, 1971). From posttest scores it was concluded that all three groups reached the first two levels: concrete level and identity level. The third group (combined exposition-interrogation) scored significant higher on the classification and formal levels. From retention scores it appeared that the scores of the first two groups decreased after a week, while the scores of the third group increased.

Tennyson concluded that exposition results in prototype formation, interrogation results in classification. If these presentation forms are not merged than the prototype will vanish because there is no classification.

Concept learning, conceived as forming conceptual and procedural knowledge, can be facilitated by manipulating instructional design variables. If these instructional design variables are chosen correctly then overgeneralisation, undergeneralisation and misconception will be reduced (Woolley & Tennyson, 1982). In order to realize these effects Merrill and Tennyson (1977) distinguished four primary presentation-forms: definition (a rule or proposition which delineates the critical attributes), expository

instances (examples or non-examples, which explain the content), interrogative examples (examples and non-examples, which present the content in an interrogatory format) and elaboration of attributes (analyses of critical attributes of interrogative examples). This model of concept formation has been expanded in several directions. Tennyson and Bartwell (1974) have developed a methodology for determining the difficulty of examples. This instance-probability analysis consists of two parts: a) a subjective rating of instances according to the difficulty of the attributes, b) an empirical analysis, based on the ability of a sample of students to correctly identify examples from a list. Determining the level of instance-difficulty takes place using an attribute-matrix. The goal of this matrix is assigning a subjective value to each instance; as a result, the difficulty range can be determined before developing learning activities. Ok Choon Park and Tennyson (1980) developed a strategy for selecting the number and determining the presentation sequence of examples. The investigation was focused on two variables of C.A.I.-based adaptive instructional strategies for concept learning. The first one was used to test the hypothesis that selection of the number of examples according to task-related information is more efficient compared with selection according to pretask-information or pretask-related information. Data analysis showed that the task-related instruction did need significantly less instruction-time and less examples compared with both other conditions. The second variable was used to contrast a response-sensitive strategy with a response-insensitive strategy to determine the presentation sequence of examples within rational sets. Tennyson and Seong Ik Park (1984) investigated the effects of manipulating the display-time of interrogatory examples. The hypothesis was that prototype-formation needs an increase in the amount of information in the initial instructional period, whereas the development of classification needs an increase of processing time in the later instructional period. Data-analysis, using posttest and retention test scores, showed that decreasing of the display- time of interrogatory examples for incorrect answers and increasing the display-time for correct answers was more effective compared with two alternative procedures: a) decreasing display-time for correct answers and increasing for incorrect answers, and b) learner-control of display-time. The instructional design model for concept learning, as described by Tennyson et. al., is based upon content-structure variables and instructional-design variables. A rational combination of these components provides the means for selection of one of four basic instructional design strategies (see appendix 1). This model of concept formation generates a number of hypotheses, some of which are tested by using the videodisc which is described in this article. It can be hypothesized from the model of Tennyson et. al. that a) instruction of concepts, which can be defined fully in terms of (separately) necessary and (jointly) sufficient attributes, will be more effective dependent upon presentation of critical attributes in combination with examples, b) students will acquire concepts faster dependent upon presentation-form: exposition-inquiry, c) as to natural categories those instructions which are organised around a prototype will be most effective, d) dependent upon divergence of defining attributes practice will be more necessary, e) generalisation and discrimination will be acquired faster dependent upon the availability of a prototype, f) the instruction of concepts will be more effective dependent upon the typicality of examples, g) the instruction of natural categories will be more effective dependent upon presentation of these categories in the context of family-resemblances, and h) learning to classify will be more effective dependent upon sequencing the objects or instances to be categorized from easy to difficult.

Design

A concept refers to a set of specific objects, symbols, events, which have common attributes and which can be referred to by a name (Tennyson, 1980). The learning of concepts involves the identification of conceptual attributes, which can be generalized to other new instances and in terms of which other instances can be discriminated from non-instances. According to the prototype theory of concept formation the student is hypothesized to generalize from a prototype to other instances for a prototype which has a strong resemblance to most of the members of a class. The student is assumed to discriminate from other non-instances for a prototype which has a low resemblance to members of other classes. According to Tennyson (1980), students who are presented a definition beyond instances and non-instances perform significantly better compared with students who are presented only instances or non-instances. There is evidence that students who are presented a definition are better in the classification of new instances compared with students who are not presented a definition. According to Klausmeier and Feldman (1975) a definition facilitates to the same degree as a rational set of instances and non-instances. In their opinion, the presentation of instances and non-instances is the most effective when the instances diverge as to variable attributes while the non-instances vary as to a minimum of critical attributes.

Tennyson and Cocchiarella (1986) have developed a theory concerning the teaching of concepts. Concept learning is conceived as a two-phase process which encompasses the formation of conceptual knowledge and the development of procedural knowledge. Prior to this theory it was stated (Jassal & Tennyson, 1981) that the proposed instructional theory for concept learning contained two mental processes: the formation in memory of a conceptual prototype and the development of the ability to recognize specific dimensions of similarity and difference between new instances. From that background the proposed instructional design guidelines contain the elements: a concept definition, the most typical example, a set of expository instances, a set of interrogatory instances and a classification test.

The two components of the model of Tennyson and Cocchiarella (1986) are content structure variables and instructional design variables. A rational combination of these components provides the instruments to select one of the four identified instructional design strategies. The four instructional design variables are: a) a definition, i.e. a rule or a generality which contains verbally the structure of the defining attributes; b) an expository instance, i.e. instances and non-instances which present systematically the content in a propositional format, c) an interrogative instance, i.e. instances and non-instances which present systematically the content in a question format, d) attribute elaboration, i.e. the prompting or the analysis of critical attributes in expository instances and feedback on the critical attributes in interrogative instances. In terms of attribute-characteristics (constant dimensions and variable dimensions) and in terms of the relational structure (successive and coordinate) Tennyson and Cocchiarella distinguish four strategies: a) strategy 1 (constant plus successive): name plus definition, best example, expository instances (successive presentation), interrogative instances (optional) and embedded refreshment; b) strategy 2 (constant plus coordinate): names plus definitions, best examples, expository instances (simultaneous presentation), interrogative instances, attribute elaboration, embedded refreshment; c) strategy 3 (variable plus successive): name plus definition, context or problem domain, best example, expository instances (successive presentation),

interrogative instances, strategy information, embedded refreshment; d) strategy 4 (variable plus coordinate): names and definitions, context and problem domain, best examples, expository instances (simultaneous presentation), interrogative instances, attribute elaboration, strategy information and embedded refreshment.

Tennyson & Ok Choon Park (1980) presented a four phase process for the teaching of concepts. The first phase contains the determination of the taxonomic structure of the content. The second phase implies the construction of a concept definition in terms of defining attributes where the instances are selected in terms of critical attributes. The third phase involves the incorporation of instances in a rational set by an appropriate manipulation of critical attributes. The fourth phase involves the presentation sequence of the rational sets according the divergence the difficulty level of instances of the concept.

Instructional design systems stress the importance of a) the description of learning outcomes, b) the execution of task analyses, c) the development of learner activities, d) the construction of mastery tests, and e) the revision of programm-contents. There is evidence (Tennyson & Boutwell, 1974) decisions as to the selection of instances are of crucial importance for the performance of the student. There are three types of errors in which concept learning is involved: overgeneralisation, undergeneralisation and misconception. Tennyson, Woolley & Merrill (1972) concluded, that the difficulty of instances is a major source of errors when learning of concepts is involved. Tennyson & Boutwell (1974) presented a method for the selection of instances. The development of a measure for instance-difficulty is a two-step function, which is referred to as instance-probability analysis. The instance-probability analysis contains two parts: a) a subjective estimation of instances according to the difficulty of attributes, and b) an empirical analysis based on the ability of a sample of students to correctly identify instances from a list. The first step when rating instances is dependent on a content expert. Expertise is necessary because the steps of this analysis imply value judgments as to relevant and critical attributes. The steps are: a) definition, i.e. the relevant attributes of the concept class to be taught, b) identification of the more common irrelevant attributes, c) construction of a attribute-matrix in order to assign scale values to each instance. Note that a concept class exists because instances have relevant attributes in common. The definition identifies those attributes by which each member must to be characterized. Two different categories of concept classes can be defined: observational concepts and definitional concepts (Gagné, 1970). The difficulty of instances will vary dependent upon the complexity of the relevant attributes and dependent upon the context in which they are used. Common irrelevant attributes are those which are not a part of the definition. The more the irrelevant attributes hide or derive from the relevant attributes the more difficult the recognition of the instance will be. The assessment of the difficulty-level of the instance is executed using an attribute-matrix. The primordial goal of the matrix is to assign subjectively a value to each instance in such a way that a difficulty range can be identified. The attributes are displayed vertically while the difficulty weights (proceeding from 1 through 5) are displayed horizontally. For each instance the content specialist determines whether it has all relevant attributes; if that is the case then it is an instance. For all instances which are used in the instruction (whether they are instances or non-instances) the difficulty as to the irrelevant attributes is assigned. After the instances and the non-instances are rated the content specialist can determine whether the spreading of the scores represents a sufficient range to divide the instances in easy, medium and difficult.

Tennyson and Cocchiarella (1986) conceive concept learning as consisting of two phases. The first phase is the formation of conceptual knowledge. The second phase is the development of procedural knowledge. The two components of their instructional design model are content structure variables and instructional design variables. By varying these components the three classification errors (Woolley & Tennyson, 1972), i.e. overgeneralisation, undergeneralisation and misconception can be avoided.

The model of Tennyson and Cocchiarella is based on the instructional design guide for concept learning, as developed by Merrill and Tennyson (1977). This guide containes the components definition (in terms of critical attributes), and instances (matching of instance and non-instance, divergent instances, sequence of instances from easy to difficult). From the research, based on the Merrill and Tennyson Model of concept learning, it appears that the form of the information does have influence on the knowledge as stored in the memory.

The model of Merrill en Tennyson (1977) consists of two design components: the content structure of a given domain and the organisation of the instructional variables. According to Merrill and Tennyson the content structure has to be analyzed from two perspectives: the relational structure between concepts and, secondly, the variability of the attribute characteristics of each concept in that domain. They imply that the relational structure of concepts can be based on their production rules. These production rules are connected to two classification abilities: generalisation and discrimination. There are two basic relations which determine the structure of the domain. These are successive and coordinate relations. In the case of successive relations learning is constrained to the development of generalisations within a concept class. When coordinate relations are involved, learning encompasses the development of skills to generalize within a concept class and to discriminate between concepts. For that reason content structures which contain coordinate relations, will primarily facilitate procedural knowledge.

The instructional program, which has been developed in order to enhance classification skills in health education, is focused on the learning of coordinate concepts. The superordinate concept is shock, i.e. a sudden reduction of blood in the human organism. Three subordinate types of shock are: a) cardial shock, resulting from heart failure, b) hypovolemic shock, resulting from blood loss, and c) septic shock, resulting from gram-positive infection. The structure of the videodisc which is used to enhance the diagnostic skills of the students, is displayed in figures 1, 2 and 3.

Figure 1: Structure of the four conditions in Module 1.

MODULE 1			
Goal, structure and scope of the instructional program			
Pretest			
Presentation of a typical instance (expository)	Presentation of a typical instance (no irrelevant symptoms)	-	-
3 x 2 random interrogative instances (defining as well as irrelevant symptoms)	3 x 2 random interrogative instances (only defining symptoms)	3 x 2 random interrogative instances (defining as well as irrelevant symptoms)	3 x 2 random interrogative instances (only defining symptoms)
Closure/end	Closure/end	Closure/end	Closure/end
Transfer test			

Figure 2: Structure of the four conditions in Module 2.

<table>
<tr><th colspan="4">MODULE 2</th></tr>
<tr><td colspan="4">Goal, structure and scope of the instructional program</td></tr>
<tr><td colspan="4">Pretest</td></tr>
<tr><td rowspan="2">Interrogative instances of septic shock with feedback until mastery is achieved</td><td>Expository instance of septic shock</td><td rowspan="2">Interrogative instances of septic shock with feedback until mastery is achieved (Marking and contrasting)</td><td>Expository instance of septic shock (Marking and contrasting)</td></tr>
<tr><td>Interrogative instances with feedback until mastery is achieved</td><td>Interrogative instances of septic shock with feedback until mastery is achieved</td></tr>
<tr><td rowspan="2">Interrogative instances of cardial shock with feedback until mastery is achieved</td><td>Expository instance of cardial shock</td><td rowspan="2">Interrogative instances of cardial shock with feedback until mastery is achieved (Marking and contrasting)</td><td>Expository instance of cardial shock (Marking and contrasting)</td></tr>
<tr><td>Interrogative instances with feedback until mastery is achieved</td><td>Interrogative instances of cardial shock with feedback until mastery is achieved</td></tr>
<tr><td rowspan="2">Interrogative instances of hypovolemic shock with feedback until mastery is achieved</td><td>Expository instance of hypovolemic shock</td><td rowspan="2">Interrogative instances of hypovolemic shock with feedback until mastery is achieved (Marking and contrasting)</td><td>Expository instance of hypovolemic shock (Marking and contrasting)</td></tr>
<tr><td>Interrogative instances with feedback until mastery is achieved</td><td>Interrogative instances of hypovolemic shock with feedback until mastery is achieved</td></tr>
<tr><td>Closure/end</td><td>Closure/end</td><td>Closure/end</td><td>Closure/end</td></tr>
<tr><td colspan="4">Transfer test</td></tr>
</table>

Figure 3: Structure of the three conditions in Module 3.

MODULE 3		
Goal, structure and scope of the instructional-program		
Pretest		
Presentation of background knowledge of shock	-	-
Interrogative instance 1 with feedback until mastery is achieved	Interrogative instance 1 + background knowledge simultaneously with feedback until mastery is achieved	Interrogative instance 1. When errors are made, background knowledge is presented.
Interrogative instance x with feedback until mastery is achieved	Interrogative instance x + background knowledge simultaneously with feedback until mastery is achieved	Interrogative instance 1. When errors are made, background knowledge is presented.
Closure/end	Closure/end	Closure/end
Transfer test		

The first module contains four instructional conditions. All of them are intended to facilitate the students in providing a correct diagnosis of some type of shock. The first instructional condition starts with a (typical) expository example of cardial shock. After having processed this example six interrogatory examples of some type of shock are presented in a random sequence. These instances are sampled from a larger pool of interrogatory instances. From each type of shock two interrogatory instances are presented. The second instructional condition is identical with the first condition except that for both the expository instance as well as from the six interrogatory instances all irrelevant symptoms are eliminated. The third instructional condition contains only six interrogatory instances from a larger pool of instances. These instances are presented in a random order. Note that in this instructional condition the expository instance has been eliminated. The fourth instructional condition is identical with the third condition except that in this condition all irrelevant symptoms are eliminated. The hypothesis to be tested is which instructional condition is the most effective one in terms if the score on the transfer test which indicates the ability to classify new (non-)instances correctly. The expectation, based on the Tennyson and Cocchiarella view of concept learning, is that the first condition (a combination of expository and interrogatory instances where defining as well as irrelevant symptoms are included) is superior compared to the other conditions due to the fact that this condition facilitates the formation of a prototype and due to the fact that this condition provides the opportunity to practice discrimination and generalisation.

The second module contains four conditions. The first instructional condition contains three sets of interrogatory instances (cardial shock, septic shock, hypovolemic shock). These instances are practiced until mastery has been reached. The second instructional condition contains three sequences: a) an expository instance of cardiac shock, followed by a variable (dependent upon mastery) number of interrogatory instances of cardiac shock, b) an expository instance of septic shock, followed by a variable (dependent upon mastery) number of interrogatory instances of septic shock, and c) an expository instance of hypovolemic shock, followed by a variable (dependent upon mastery) number of interrogatory instances of hypovolemic shock. The third instructional condition is identical to the first one except that in the third condition relevant attribute-values are marked or contrasted. The fourth instructional condition is identical to the second condition except that in the fourth condition relevant attribute-values are marked and contrasted. The hypotheses to be tested is which condition is the most effective one in terms of the number of correctly classified new patients. The expectation is that the fourth instructional condition will be the most effective one due to the fact that in this condition the formation of a prototype will be more facilitated compared to the other conditions.

The third module contains three instructional conditions. All of these three conditions contain a set of interrogatory instances. These instances are practiced until mastery has been reached. The distinctive feature of instructional condition one is that prior to the presentation of the interrogatory instances a knowledge base (consisting of prerequisite knowledge such as heart, heart failure, heart frequency and so on) is presented to the students. In the second instructional condition this knowledge base is presented simultaneously with the practice of the interrogatory instances. The third condition is characterized by the fact that the knowledge base of prerequisite knowledge is presented during those moments when classification errors are made. The expectation is that the

third condition will be superior compared to both of the other conditions due to the fact that in the third condition the prerequisite knowledge is activated at those moments when it is necessary. This will result in the facilitation of discrimination and generalisation.

Reason and motivation for choosing a videodisc program

As was pointed out in the previous section, diagnosis can be conceived of as a process of categorization. Some representation of shock must also be available. Because sound, as well as motion and image, can represent critical symptoms, the choice for video was easily made. Besides, to provide the learner with more than one instance of shock, the possibility to have immediate access to the instances is a necessity. Only a videodisc can meet these demands. Another important advantage of using a videodisc is the possibility of using different information channels (printed text, speech, animation and images) in an integrated whole (Handbook Interactive Video, 1988). The integration of computer text and image with either still or motion video is accomplished by the DVA-4000 VideoLogic-card which digitalizes the analogous video signal so that it can be presented on a VGA computer monitor together with text and graphics.

The content of the videodisc program can also be subdivided into two categories. First there is the large number of instances of shock, and second there is the knowledge framework which encompasses some animations and background information regarding the blood circulation, the heart, etc. To be sure that all information is correct and no mistakes are made, the content is continuously reviewed by a medical expert.

Recordings

To obtain the 30 examples of shock and the four non-examples of shock, video recordings were made. First, the recording of real patients in hospitals was begun. This had a number of disadvantages. To minimize the bias in this research program, it was necessary to abstract from non-relevant details; all patients had to be recorded in a standard way. This was not possible in the real situation. Second, the privacy aspect of the patients or relatives was an important issue. Some patients died a few days after they were recorded and it was not ethically correct to use these recordings. The third disadvantage was that for this study exactly 10 examples of each type of shock were needed. Some types of shock occur however more frequently than other types so it was difficult to record all these examples.

The solution was found in so called LOTUS[1]-patients. With lotus patients it was possible to record 10 examples of the three types of shock in a standard way. First a total shot of the patient was recorded, than a close up of the face, a close up of the breast and rump, a close up of the hand and finally the foot.

One problem here was to assure the reality of these recordings. Because everything

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[1]LOTUS is the dutch abbreviation for Landelijke Organisatie Tot Uitbeelding van Slachtoffers. This is an organization for the depiction of victims. These actors are being used for example for films, exercises of the fire department and so on.

was recorded at the studio of the Department of Education at Twente University, a whole intensive care environment had to be simulated including a hospital bed, intensive care pyjamas, infuse, connections for the monitor, oxygen supply and medical attributes near the bed. A medical expert was present at each recording session to instruct the players as well as to verify the make up.

Separately all monitor data were recorded. The values of the monitor parameters were obtained via two simulators and recorded with a special camera to prevent the image from flickering. Finally a presenter was recorded. He made the announcements of the different parts in the videodisc program. The presenter was recorded the same way as a normal television presenter.

The audio part consists of "life" environmental sound as well as spoken comment. These spoken comment texts were recorded separately.

Editing

To obtain a master tape for pressing the videodisc, a 36 minute long version of all recordings had to be edited. A special architecture of the videodisc was designed. We used the video track for all images. The foot as well as the monitor data were edited as stills whereas the hand was edited as partial still: the first three seconds a normal hand is laid over the patient's hand, then the image is freezed. The environmental life sound was mixed with the spoken text on audio track 1 in such a way that no important information was lost. Audio track 2 was used for spoken text which belonged to the stills. With the DVA-4000 card of VideoLogic it is possible to display the still first and then play the accompanying text. To keep up the speed the spoken text was edited as closely as possible to the place the stills were edited. In less than 0.7 seconds the audio can be searched. In this way a 36 minute long tape could be obtained. Digitizing the audio was not possible because of the huge amount of memory space which was needed.

Screen design and user-interface

The program offers different options for the user which can be selected by clicking the mouse on certain buttons. The number of buttons was minimized to make the program more user friendly. Fixed screen parts were used for the same information. For example, the video image is always shown in the upper left corner of the screen, whereas questions, answers and feedback always appear in the lower part of the screen. In this way the user can always expect certain information on certain places on the screen. The background colour is a sort of green which is chosen so that text in black letters is clearly readable. According to Heuvelman (1981) a redundant presentation of information enhances retention. The redundancy theory states that redundant information facilitates information processing. For this reason the video image in the case of expository instances (see above) is supported by key words in the right margin.

In the case of an interrogatory instance of shock, the user should provide a correct diagnosis. To provide a correct diagnosis can be seen as making a correct classification. In this case the object is an patient with a particular disease which has certain attributes or symptoms. The disease has to be classified. One of the main features is that the user can select video sequences he wants to replay so that he can examine the patient until he has seen enough symptoms to provide a diagnosis. For each video sequence a picture is available which refers to a particular sequence in an exemplary manner. After clicking, the

picture the video sequence is shown and the picture is marked to provide orientation for the user. The user can click as many times he wants on a picture to replay a sequence. At any time, the user can click on the diagnosis button. He is asked then for a diagnosis. When the diagnosis is wrong, the user will receive the advise to watch certain video sequences.

Technical state of the art

Storage media

At this point it seems desirable to mention a few points about the videodisc and its "competitors" for there are a large number of platforms on which interactive video can be developed and still other platforms are being developed. There are a number of media in which information (video, audio, text, etc.) can be stored. These media can be divided into two groups: magnetic tapes and discs (magnetic as well as optical). The second group has the shared common feature of quick random access to data and is therefore of particular interest in interactive learning environments. These media will be focused upon in the following text.

First of all a distinction has to made between analogue and digital recording. Analogue recording is very efficient. Although one single video frame could hold about 1.2 MB[2] of data if it would be digitized, in analogue form it can be easily stored. Examples of analogue media are laservision disc and video tape. Digital recording on the other hand is much more flexible: data can be transferred, copied, manipulated, integrated with other data and so on. The problem however is becoming immediately clear, the enormous amount of data which is necessary to produce only a few seconds of full screen full motion (FSFM)[3] video is running out of hand. A CD-ROM for example, with a capacity of over 600 MB can hold about 30 seconds of FSFM video and even then this medium can only deliver about 150 KB per second so that it can produce only one frame every 5 seconds instead of the required 25 or 30 (PAL or NTSC) frames each second. So several compression techniques are being developed to reduce these amounts of data.

A second distinction can be made between optical and magnetic storage. Magnetic media have the advantage of easily recording and erasing data together with fast access rates. Information is stored or erased by simply polarizing magnetic particles on the surface of the disc. The capacity of these discs is often limited. Optical discs generally offer much more capacity but access time is relatively slow and an external drive is required. Data is stored in a pattern of shallow pits on the surface of the disc and is read by means of a laser beam. Examples are the compact disc (digital) or the laservision disc (analogue). Advantages are that these media are removable and much less vulnerable.

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[2] A full sized picture measures 768 x 576 pixels. For each pixel the RGB signal is encoded in 3 x 8 bits or 3 bytes. 768 x 576 x 3 = 1,335,804 bytes which is approximately 1.2 MB.

[3] Full motion video in PAL is shown at a rate of 25 frames per second whereas in NTSC this is shown at a rate of 30 frames per second.

A third distinction can be made between writable and non-writable discs. Write-once discs such as DRAW (Direct Read After Write) and ODC (Optical Disc Corporation), which both are analogue, WORM (Write Once Read Many), which can be both analogue or digital and CD-WO(RM) (Compact Disc-Write Once (Read Many)) which is digital, are frequently used as check discs during the last stage of the production. Information can be real time recorded instead of pressing the disc in mass-volume replications. The most common draw backs are video quality and liability to deterioration. These write-once disc don't provide the possibility to update data because these discs are not re-recordable. An example of a re-recordable disc is the hard disc (with limited capacity). To record a high volume optical disc a strong laserbeam should melt the surface of the disc to erase existing data and than cut the new data into the smoothed surface.

Figure 4 shows a number of storage media grouped according to the three dimensions mentioned above.

Figure 4: Storage media subdivided according the dimensions writable/non-writable, optical/magnetic and analogue/digital.

	Optical data formats		Magnetic data formats	
	Analogue	Digital	Analogue	Digital
Writable	CRV-disc WORM DRAW ODC	CD-WO(RM) (*Orange book*)	Videotape Audiotape Tape	Hard disk Floppy disk
Non-Writable	LaserVision LaserDisc (CD-V)	CD-DA (*Red book*) CD-ROM (*Yellow book*) CD-ROM XA (*Yellow book*) CD-I (*Green book*)		

Compression techniques

Above the problem of the enormous amount of data in the case of digital storage was mentioned. The solution of this problem lies in data compression. Three variables can be manipulated: a) compression rate, b) image size/resolution and c) frame rate.

DVI (Digital Video Interactive) perhaps is the most known in this field. It incorporates several compression techniques and allows three types of video processing: PIC (Picture Image Compressing) is still image compression using the JPEG[4] standard, RTV (Realtime Video) which provides realtime compressing and playback of motion video at intermediate quality and, third, PLV (Presentation Level Video), which is done off-line but provides the best quality (near TV) motion video playback.

Videologic provides FSFM video using the JPEG standard. Each frame is separately compressed according to the JPEG standard. Just by showing this pictures at a rate of 25 or 30 frames a second, motion video is realized. This means that high quality video can be stored and replayed but only when using a fast, high capacity hard disk. When CD-storage media (with lower access times) are used, the compression rate has to be increased which means that the quality of the frames decreases, or the window size decreased to replay full motion video sequences.

Apple Macintosh lately came out with QuickTime, a multimedia program for the user. Three different forms of compression are used: the photo compressor fully supports JPEG (JPEG compressed pictures can be translated into the photo compressor's format) and compresses still images at a ratio of 10:1. The animation compressor for compression

[4] JPEG: Joint Photographic Experts Group. This is the international consortium of hardware, software and publishing interests dedicated to developing international standards for the compression of still photographic images in digital systems.

of animations is based on run-length encoding techniques[5]. Finally the video compressor with compression ratios from 5:1 to 25:1 allow video image at one-eight of the screen at 15 frames a second. In the future QuickTime will support MPEG compression too.

To achieve higher compression ratios for motion video the MPEG standard is currently being developed. In the case of the MPEG standard, data is reduced to the absolute minimum necessary to show motion video, whilst at the same time achieving a standard of visual presentation which is acceptable to the viewer. Showing still picture embedded in sequences is not possible when using this standard.This problem can be solved by recording still images separately and compressing them according the JPEG standard.

One of the most impressive current compression techniques is fractal compression with compression rates of 1000:1. In short this technique uses formulas to describe fractal shapes[6] in the picture. Although quality and speed are not as good as some other compression techniques, fractal compression is very cheap and can be used on a simple PC.

According to P. Fletcher (1992) the ultimate in multimedia systems would provide full screen, full motion (25 or 30 frames per second) video, high-fidelity audio, text, computer graphics and animation whereby all the hardware is stored in one box and all the software on a single medium such as compact disc.

Formative evaluation

Method

After a prototype version with three examples was completed, a formative evaluation was conducted. The purpose of this evaluation was to check which improvements should be made before the next phase in the project was entered: the implementation of all 34 examples.

The prototype version was developed exactly in accordance with the design specifications; that means that the program looked just the way the final program would look. There was only one exception, the prototype contained only three instances of the disease shock: one expository instance and two interrogatory instances. This implied that instances in the prototype were not randomly selected from a large number, but were presented in a fixed order.

Ten experts in the field of educational technology and with experience regarding interactive video have individually worked with the program. There were no time limits. During the session the subjects were allowed to ask questions when the program provided

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[5] Run length encoding (RLE) is a graphic format, which encodes the colour of the first pixel in a line, and then records the length (in pixels) for which this colour runs, until another colour appears.

[6] A fractal is a pattern which reveals itself in higher and higher levels of detail. A simple geometrical shape can turn into a very complex irregular shape such as a cost line, a mountain range and so on, just by repeating itself at higher levels.

no clear instruction about the next action. All questions were answered shortly and then recorded. The subjects made notations about positive and negative points they noticed.

After the subjects had completed the program, they were given a questionnaire. The questionnaire contained 42 statements about the program. The subjects were asked to score the statements on a five point scale according to their opinions. The statements were categorized in seven groups:

1. Information channels
2. Sequencing of the instruction
3. Questions
4. Screen design
5. User interface
6. Informational accuracy
7. Attractiveness

Finally, after completion of the questionnaire the subjects were interviewed. They gave comment on what they had written down during the session and the most negative points of the program according to the subject were discussed. Finally the subjects gave suggestions for improvements. Everything was accurately recorded.

Results

Frequency tables were constructed to analyze the questionnaires. One question about the sequence of the instruction concerning the backgrounds of shock was omitted because this explanation was not given in the program.

Because of the qualitative character (instead of quantitative) of the questionnaire, standard deviations were not computed. There was however a strong tendency in the scores of many of the questionnaire's statements. The scores with the strongest tendency were selected first. With the results from the interviews, proposals for improvements were made.

Improvements made

One of the main characteristics of the videodisc program is the difference between expository and interrogatory instances. Suggestions for the improvement of this aspect were seen as most important and superior to other suggestions. The results have led to many improvements. The most important among them will be shortly described below.

First the structure of the interrogatory instances has been changed. The purpose of the program is that users can classify an object (in our case the disease "shock") into an specific category. It's important therefore that users can examine the object. Questions have the function of leading the attention of the learner and to help the learner think. The structure of the interrogatory instances now is as follows: they encompass a) an initial video presentation where the patient is presented linearly without the possibility for interaction, b) a secondary presentation encompasses the different aspects of the human body (e.g. face, hand, foot) as well as the monitor data (e.g. heart frequency, blood pressure, respiration, etc.). In this phase the student can choose one aspect about which he will receive a question. Before answering this question he can optionally view the relevant video sequence. The learner can also turn directly to the diagnosis. When a wrong answer is given, the learner will receive hints and will get new opportunities to examine the patient.

The changes in the interrogatory structure led also to changes in the user interface. Together with comments concerning presentation of information this led to a number of criteria which were the basis of many improvements:

- the number of buttons with different functions was minimized,
- clear instructions for the user were submitted to the program,
- the video image was enlarged,
- information via different information channels was tuned and used more consequently,
- text with a high information density is always (also) presented visually,
- jargon and normal language is used more consequently

References

Bolton, N., (1977). Concept formation. Oxford: Pergamon Press.

Carey, L.C., (1975), Shock: Differential diagnosis and immediate treatment. In: Hospital Medicine.

Cohen, B., (1982), Understanding natural kinds, unpublished doctoral dissertation, Stanford University.

Cohen, B., Murphy, G.L., (1984) Models of concepts. Cognitive science, 8, 1, 27-59.

Fletcher, P. (1992). Introducing multimedia. In J. Ayre, J. Callaghan & S. Hoffos (Eds.) The European multimedia yearbook 1992. Interactive Media Publications Limited: London.

Glaser, R. (1976), Components of a psychology of instruction: Toward a science of design. Review of educational research, 46, 1-24.

Jassal R.S. & Tennyson, R.D. (1981). Application of concept learning research in the design of instructional systems. International Journal of instructional media, 9, 3.

Merrill, M.D., Tennyson, R.D., (1977). Teaching concepts: An instructional design guide. Educational Technology Publications. Englewood Cliffs: New Jersey.

Nowakowska, M., (1977). Methodological problems in measuring fuzzy concepts in the social sciences. Behavioral science, 22.

Perry, Potter (Eds.) (1983). Shock: Comprehensive nursing management. The Mosby C.V. Compagny: St. Louis.

Quine, W.V.O., (1960). Word and object. Cambridge: Mass.

Riecher, G. (Ed.), (1984). Shock, Handbuch der inneren Medizin. Springer Verlag: Berlin.

Rosch, E., (1978). Principles of categorization. In: Rosch, E. and Lloyd, B.B. (Eds.), Cognition and categorization. Hillsdale, N.J.: Erlbaum.

Rosch, E., Mervis, C.B., (1981). Categorization of natural objects. Annual Review of Psychology, 32, 89-115.

Rosch, E., (1975). Cognitive reference points. Cognitive Psychology, 7, 532-547.

Tennyson, R.D., Seong Ik Park, (1984). Process learning time as an adaptive design variable in concept-learning using computer-based instruction. Journal of educational psychology, 76, 3, p. 452-465.

Tennyson, R.D., Cocchiarella, M.J., (1986). An empirically based instructional design theory for teaching concepts. Review of Educational Research, 56, 1, p. 40-71.

Tennyson, R.D. & Ok Choon Park. (1980). The teaching of concepts: a review of instructional design literature. Review of educational research, 50, 1, 55-70.

Tennyson, R.D. & Boutwell, R.D. (1974). Methodology for defining instance difficulty in concept teaching. Educational Technology.

Tennyson, R.D., Ok Choon Park, (1980). The teaching of concepts: a review of instructional design literature. Review of Educational Research, 50, 1, p. 55-70.

Tennyson, R.D. & Cocchiarella, M.J. (1986). An empirically based instructional design theory for teaching concepts. Review of educational research, 6, 1, 40-71.

Wittgenstein, L., (1953). Philosophische Untersuchungen. Oxford.

Woolley, F.R., Tennyson, R.D., (1972). Conceptual model of classification behavior. Educational Technology, 12, 37-39.

Zadeh, L.A., (1982). A note on prototype theory and fuzzy sets. Cognition, 12, 291-297.